Transformative versus conservative automotive innovation styles: contrasting the electric vehicle manufacturing strategies for the BMW i3 and Fiat 500e

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1. Introduction

The global automotive industry is both vast in its complexity and vital to the lifestyles of many residents in the industrialized world. Cars not only make transportation easier, but are associated with a sense of freedom and economic accomplishment (Sovacool and Brossmann 2014). In many countries vehicles represent 20 percent or more of national retail sales and 20 percent or more of manufacturing output (Mitchell et al. 2010). Orsato and Wells (2007: 990) write that “there are few industries as large, diverse and influential as the automotive industry.” Also, the automotive industry is inherently innovative and has the third highest industry rating for R&D, accounting for 15.5% of global research and development spending in 2017 (Statista 2017). The automobile industry thus must design, refine, and orchestrate complex supply chains necessary to create a high value mass product that spans multiple other industries including mechanical engineering, materials science, electronics, and information and communication systems (Pries 2006).

Because of this intricacy and complexity, the firms making automobiles, the original equipment manufacturers (OEMs), are a key player in the industry. Rong et al. (2017: 236) argue that “the OEMs in the EV industry are the ecosystem keystone players or orchestrators to coordinate the other stakeholders in obtaining knowledge mobility (during the design of new EVs), innovation appropriability (sharing profits in the EV ecosystem) and network stability (selection of EV ecosystem partners).” Understanding how automotive firms innovate is an elemental part of describing and then comprehending their patterns of research and development.

Nonetheless, the production and manufacturing processes for automobiles are not uniform. Automobile manufacturing in Japan was characterized historically by an emphasis on long-term growth, high levels of automation, skilled managers, and a focus on production *methods*, whereas in the United States it was marked by an emphasis on short-term growth, high legacy costs (to unions), delegation of authority to less skilled workers, and a focus on production *results* (Cusumano 1988; Abu 1995; Kawamura 2010). In Sweden, automobile manufacturers were renowned for putting safety before profits, yet in Russia, managers put profits arguably above safety (Dodourova. 2005). Lane and Bachmann (1996) hold that British carmakers have less trust in their suppliers, German carmakers more. Hård and Knie (2001: 93) even argue that the making and use of automobiles cannot survive without “cultural ambience”—the necessity for a technology to find a space within the overall social or cultural “atmosphere.” Consequently, the manufacturing of automobiles does exhibit, and perhaps perpetuate, distinct cultural traits.

This leads us to ask in this paper: how do innovation profiles or approaches differ when one assesses an emerging innovation such as the manufacturing of modern EVs? More concretely, how do traditional car manufacturers such as BMW or Fiat respond to carbon reduction targets and electric vehicle quotas? We focus on EVs because they are often mentioned as holding potential to play a strong role in decarbonizing the transportation sector. For example, in scenarios produced by the International Energy Agency (2010) to achieve long term climate goals, EVs need to achieve a 40% new vehicle market share by 2040. Conventional automobiles are also major sources of particulate matter which is associated with heart disease, cardiopulmonary disease and atherosclerosis. Moreover, EVs offer a host of other potential co-benefits such as improved performance, quieter operation, and lower lifetime fuel costs.

More specifically, this study qualitatively examines two case studies of two models of electric vehicle: the BMW i3 and the Fiat 500e. Together, both BMW and Fiat-Chrysler constitute major automotive manufacturers because they sell more than 6 million vehicles a year. The BMW i3 was designed in-house with a corporate strategy wrapped in hopes that it will become the “future” of electric mobility. The BMW advertising campaign for the i3 proudly proclaimed “Hello Future” and noted “the future of electric mobility is here.” The Fiat 500e, by contrast, is the literal “black sheep” of the Fiat-Chrysler family, made only to appease stringent emissions targets in California, and intended not to be sold. The cases offer a useful contrast showing the similarities and differences that arise when automotive firms attempt to innovate—or not. In examining these two cases, we hope to make an empirical contribution alongside a conceptual one. Empirically, we explore how the innovation trajectories of BMW i3 and Fiat 500e differ, with clear implications for better comprehending how the automotive industry operates. Conceptually, we attempt to apply a TIS framework to a corporate product, a branded vehicle, and to assess the diverging innovation styles of two globally active incumbent car manufacturers.

The paper proceeds as follows. It first introduces our integrated conceptual framework which merges together technological innovation systems, or TIS, with corporate product innovation styles. In the next section, it explains the rationale for our case study selection and describes the methods used to collect data. We then present our two qualitative case studies of the BMW i3 and Fiat 500e before offering our conclusions and implications.

2. Technological innovation systems and global corporate product innovation: A synthesis

As a guiding conceptual lens to help us examine our cases and filter our data, we tie together two usually disparate threads of academic scholarship: technological innovation systems and corporate product innovation. We also explain via our synthesis why we utilize a global or multi-scalar lens in examining our two case studies.

2.1 Technological innovation systems

In this article, we tie corporate product innovation thinking with that of Technological Innovation Systems, or TIS. In the field of transition studies socio-technical changes that lead to more sustainability are mostly analyzed from a systems perspective which pivots around the idea that innovations are the result of complex interactions between various actor constellations that happen under varying institutional circumstances. Building on the national systems of innovation literature (Freeman, 1987, 1995; Lundvall, 1992), different approaches have been developed which focus on varying boundaries to the innovation system in question (Planko et al., 2017, p. 616): regional, sectoral, corporate, and technological innovation systems.

Our analysis focuses on two new technological products, namely the BMW i3 and the Fiat 500e. For this purpose, the technological innovation systems (TIS) approach seems to be the most suitable. The TIS approach is concerned with the analysis of emerging technologies (Bergek et al., 2008a; Musiolik and Markard, 2011; Reichardt et al., 2017). Compared to internal combustion engine vehicles (ICEVs) electric vehicles (EVs) have been an inconsequential niche product since the early 20th century (Altenburg, 2014). Therefore, although EVs have quite a long history they are still an emerging technology.

A TIS is defined as a “socio-technical system focused on the development, diffusion and use of a particular technology (in terms of knowledge, product or both)” (Bergek et al., 2008b, p. 408). Although this definition may imply some kind of collective action, a TIS is primarily an analytical construct which allows to focus on the interaction between the different components of the system. Typically, a TIS is analyzed in both structural and functional terms. The structural components are actors, networks and institutions (Carlsson and Stankiewicz, 1991). The actors may include firms or sub-units of firms, research organizations, universities, government bodies, interest organizations, non-governmental organizations etc. Actors are linked by various types of networks, e.g. learning or political networks. Interactions between the actors are regulated by institutions such as norms, laws, cognitive rules and frames, values, culture, collective expectations and imaginaries and so forth (Bergek et al., 2008b; Musiolik and Markard, 2011). The TIS approach thus "highlights both the role of institutional structures and the importance of organizational actors in the emergence of technological innovations" (Musiolik and Markard, 2011, p. 1910).

In functional terms Bergek et al. (2008b) have identified seven key processes to assess the overall performance of a TIS and to compare different innovation systems: knowledge development and diffusion, influence on the direction of search, entrepreneurial experimentation, market formation, legitimation, resource mobilization, and the development of positive externalities. The seven functions are described in Table 1.

Table 1: Seven functions of Technological Innovation Systems

Function	**Description**
Knowledge development and diffusion	Broadening and deepening of the knowledge base of a TIS, sharing of knowledge between actors within the system and new combinations of knowledge as a result of these processes.
Entrepreneurial experimentation	Problem-solving and uncertainty reduction through real-world trial-and-error experiments at different scales with new technologies, applications and strategies.
Market formation	The opening up of a space or an arena in which goods and services can be exchanged in (semi-)structured ways between suppliers and buyers, including e.g. articulation of demand and preferences, product positioning, standard-setting and development of rules of exchange.
Influence on the direction of search	Mechanisms that influence to what opportunities, problems and solutions firms and other actors apply their resources, incentivizing and pressuring them to engage in innovative work within a particular technological field and determining what strategic choices they make within that field.
Resource mobilization	The system's acquisition of different types of resources that for the development, diffusion and utilization of new technologies, products and processes, most notably capital, competence and manpower and complementary assets (e.g. infrastructure).
Legitimation	The process of gaining regulative, normative and cognitive legitimacy for the new technology, its proponents and the TIS as such in the eyes of relevant stakeholders, i.e. increasingly being perceived as complying with rules and regulations, societal norms and values and cognitive frames.
Development of positive externalities	The creation of system-level utilities (or resources), such as pooled labor markets, complementary technologies and specialized suppliers, which are available also to system actors that did not contribute to building them up.

Source: Bergek et al. 2018

Even though Bergek and colleagues state that "TISs may have a geographical dimension, but are often international in nature" (Bergek et al., 2008b, p. 409) most TIS studies have focused on dynamics on a national level (Binz et al., 2014; Binz and Truffer, 2017; Quitzow, 2015). Moreover, the TIS literature falls short of addressing how the interplay of international policy targets influence the development of a TIS (Quitzow, 2015, p. 128). Existing studies are concerned with the influence of national policies on the development of domestic TIS and compare different national development trajectories (Andreasen and Sovacool, 2015) but have not analyzed the emergence of different TIS in response to international, non-domestic policies.

One of the most important considerations TIS analysts face is whether to choose a knowledge field or a product as a "focusing device" (Bergek et al., 2008b, p. 411). Existing TIS analyses have mostly focused on knowledge fields or a single technology, e.g. wave power (Hannon et al., 2017) or solar PV (Quitzow, 2015). The automotive industry is characterized by very complex value chains, an aspect which is often neglected in the TIS literature (van Welie, Truffer 2018).

A transition towards battery electric vehicles involves some degree of systemic changes along the value chain from production to consumption. Furthermore, if battery electric vehicles prove to be a success highly depends on context structures and the development in other TISs (Bergek et al., 2015), e.g. the development of battery technology (Stephan et al., 2017). To remedy the situation, we argue that the TIS approach can also be used to study and compare the innovation dynamics around specific products. Similar to a study on two competing technological innovation systems for heavy transport (Magnusson and Berggren, 2018) we analyze two competing TIS around two different products from the same product group: battery electric vehicles.

2.2 Corporate product innovation styles

We not only examine the functions of innovation occurring as part of a TIS. We also assess corporate product innovation, namely how corporate actors—firms or in this case automotive manufacturers—develop and then push new products and services into the market (Hargadon and Douglas 2001). We broadly call this corporate innovation "style" (Coombs and Tomlinson 1998; Sovacool et al. 2017). Battistella et al. (2012) note that such innovation processes span product development as well as user-centered design. In some cases, corporate innovation can focus not on a specific technology or material artifact, but on changing or innovating the meaning attached to a technology. Verganti (2008) gives the example of the Swatch (watch) in the 1970s and 1980s, where the radical change was not in the manufacturing or performance of the watch but in altering its meaning from an instrument of time or a piece of jewelry to a type of fashion accessory.

Although large, the body of literature on corporate product innovation styles suggests that firms can play an instrumental role in developing new innovations and changing consumer mindsets. Rosenkopf and Nerkar (2001) find that organizations that position themselves to cross organizational and technological boundaries have higher positive effects on technological evolution than those that stay within established boundaries. In his seminal book, Christensen (1997) distinguishes between disruptive and sustaining technologies. Disruptive technologies "bring to a market a very different value proposition than had been available previously" whereas sustaining technologies "improve the performance of established products, along the dimensions of performance that mainstream customers in major markets have historically valued" (Christensen 1997: 11). He argues that this distinction is very different from the established distinction between radical and incremental. In his view, some sustaining technologies can be incremental, while others are more radical but all sustaining technologies have in common that they follow a rather consistent path (Christensen 1997: 39).

Within the realm of low-carbon technology in particular, multiple studies have suggested that the success of new energy alternatives such as offshore wind turbines or electric vehicles will depend entirely on new forms of corporate innovation to be successful (Awate et al. 2012; Heponstall et al. 2012). Wesseling, Farla and Hekkert (2015) explore car manufacturer responses to California's Zero Emissions Vehicles (ZEV) mandate. Building on Oliver and Holzinger (2008), they distinguish between value creating, early-mover strategies on the one hand and value maintaining, laggard strategies on the other. Value creating strategies focus on pioneering through heavy investments in R&D and quick commercialization of innovations. Value maintaining strategies aim for the exploitation of the status quo and minimizing costs, hence they result in little investments in R&D and a "focus on cheap compliance options" (Wesseling et al., 2015: 93). Wesseling et al. (2015) conclude "that firms combine innovation and political influence strategies to exploit strategic synergies" and "that firms change their strategies over time, generally from value maintaining strategies to value creating strategies" (Wesseling et al., 2015: 101-2).

When applied specifically to EV manufacturing, Sovacool et al. (2017) discuss various tensions in innovation styles, noting that some firms may promote organizational and stakeholder involvement, others may restrict it. Some firms may prefer decentralized coordination and control; others centralized. The authors typify Volkswagen as relatively “closed” (more rigid, more proprietary, and more controlling) and Tesla as relatively “open” (more flexible, more open to sharing information, and more dynamic).

2.3 Synthesis

Marrying these conceptualizations together, we can differentiate between two incumbent innovation styles in dealing with automotive EV innovation. The first is *transformative change-shaping*: a value-creating, more radical approach with heavy investments in R&D and the aim for early commercialization, hoping to create the capabilities for profitable breakthroughs through transformative learning. The second is *conservative sustaining*: a value maintaining approach with less investments in R&D, limited learning and a focus on cheaper compliance options, not grounding strategy in the hopes of a profitable breakthrough. Whereas the conservative sustaining innovation is grounded in the managerial assessment of the “sustainability” of the market, the transformative change-shaping innovation style arises from the assessment of the “disruptability” of the market (Schmidt and Druehl 2008: 363). However, following Christensen (2007) we argue that disruptive is a characteristic of technologies and innovations rather than innovation *styles*. For this reason, we distinguish between a change-shaping and a sustaining innovation style.

As Figure 1 indicates, we propose a spectrum exists, from *transformative change-shaping*, ground-up innovation around a dedicated BEV design (Tesla; BMW i3), to more constrained but still purpose-specific design (Nissan Leaf), to more pragmatic, *conservative sustaining* adaptation of an existing model with subsequently constrained electric performance (FIAT 500e; VW eGolf). This is precisely a strong factor explaining our selection of the BMW i3 and Fiat 500e case studies.

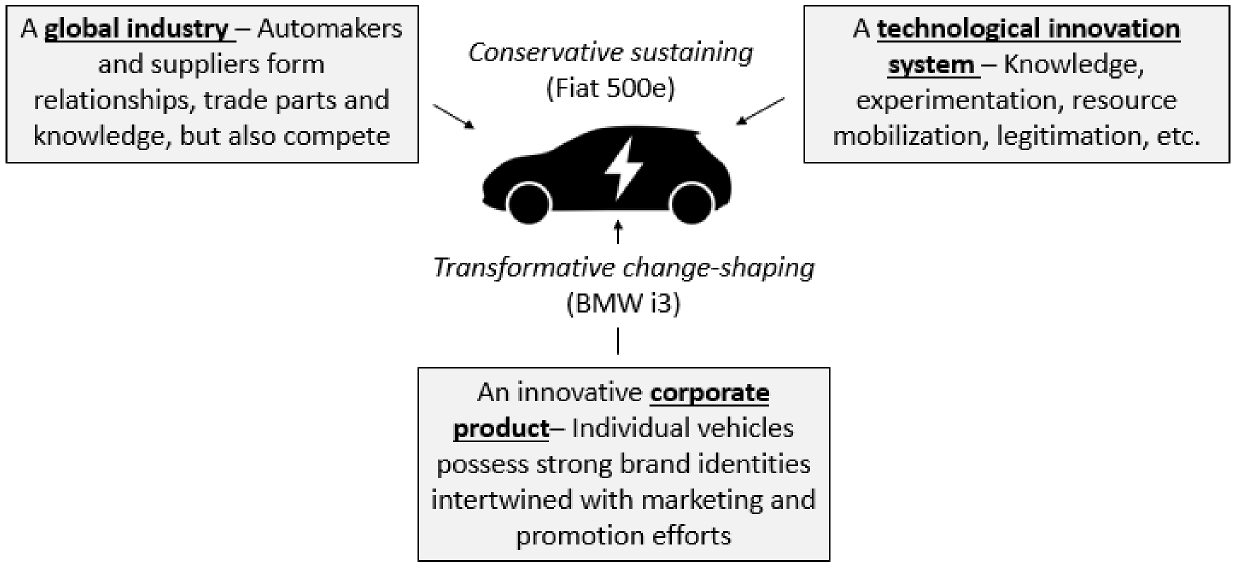
Figure 1: Change-shaping versus sustaining innovation styles for EVs

Source: Authors

Because automotive corporations, their supply chains, and their manufacturing processes often span geographic space, we lastly examine our two case studies through a global lens that includes multi-scalar supply chains and multiple countries. This is because we wanted to capture the “international interdependencies in the innovation process” (Binz and Truffer, 2017, p. 1284) to emphasize the transnational nature of the dynamics in corporate product innovation. According to Binz and Truffer (2017, p. 1293), EVs are an example of what they call a production-anchored global innovation system with a local innovation subsystem based on doing, using, interacting (DUI) learning and highly standardized global valuation subsystems. Although they expect the automotive innovation system “to get deeply transformed over the next decades” (Binz and Truffer, 2017, p. 1293), this categorization highlights the interdependencies between local innovation subsystems, in our case the development of battery electric vehicles and the global valuation system. Binz and Truffer also argue that the structural coupling between different the different subsystems is crucial for the global diffusion of innovation; “examples of coupling domains could be an internationally active firm that is able to connect knowledge resource from a regional innovation system to market segments in distant places (Binz and Truffer 2017, p. 1287).

We attempt to capture the global, technological and corporate dimensions in Figure 2, which shows how we expect the development of the BMW i3 and Fiat 500e to be shaped by global pressures, technological innovation systems, and corporate strategies—creating a complex multi-scalar system. We will touch on many of these themes in our discussion of the two cases (in Sections 4 and 5) and again return to it in the conclusion (section 6).

Figure 2: The global, technological, and corporate dimensions shaping EV development



Source: Authors

3. Case selection and research methods

This section justifies our focus on the BMW i3 and Fiat 500e before explaining our research methodology, namely consisting of document analysis and qualitative case study comparison.

3.1 Case study selection

As mentioned above, we selected the BMW i3 and the Fiat 500e because we propose these two cases offer extreme or illustrative examples on a spectrum between *transformative change-shaping* and *conservative sustaining* innovation strategies. BMW (short for *Bayerische Motoren Werke*) is a traditional automaker for luxury, premium brands of vehicles, with a history of incrementally innovating for ICE vehicles since its founding in 1928. Since the 1990s, it has introduced BEV and plug-in-hybrid models. BMW possesses an international supply-chain integrating designs at Germany’s headquarters with overseas build-to-order assembly lines and external suppliers. The BMW Group produces vehicles under three premium brands: BMW (which also makes motorbikes), MINI and Rolls Royce. By the end of 2017, the BMW Group had 129,932 employees, delivered 2.46 million vehicles globally (excluding motorbikes), generated EUR 88.5 billion in revenues within the automotive segment, EUR 98.7 billion as a group, and EUR 10.6 billion EUR profits as a group (BMW Group 2018a).

The BMW i3 in particular was the first mass production car by a major German car manufacturer that was designed and constructed solely with an electric powertrain. As BMW's first "pure" BEV, it has become the second bestselling brand of EVs across all of Europe (even when competing with PHEVs).

Fiat was founded in 1899 as Fabbrica Italiana Automobili Torino. Today, Fiat (now known formally as Fiat Chrysler Automobiles, or FCA, after a merger with Chrysler) is a leading Italian industrial group, with a total workforce of over 198,000 employees. FCA encompasses various brands including Abarth, Alfa Romeo, Chrysler, Dodge, Fiat, Fiat Professional, Jeep, Lancia and Ram brands and SRT performance (Fiat Chrysler Automobiles 2017). In 2017, FCA shipped 4.4 million vehicles, had net revenues of €110.9 billion and net profits of €3.5 billion. FCA dominates the (admittedly small) European compact car market, with the Fiat 500 and Panda accounting for 29.1 percent of all market share for minicars.

Produced under the "Fiat" brand of FCA, the 500 is arguably the flagship vehicle of the entire FCA group. Also, the 500 is the most popular (in nominal terms only) Fiat model in the USA, with 12,685 units sold in 2017. Originally designed in 1950s post-war Italy to get Italian families on the move affordably, the modern Fiat 500 is promoted on the grounds that it resembles the "chic and retro" styling for which the car has become so popular – 2017 European sales were up 3.5% to 191,400 vehicles sold (Automotive World, 2018). The Fiat 500e is fundamentally an EV conversion, modelled on the popular, retro, Fiat 500. The 500e is the first BEV offered from the entire FCA.

As a critical factor for our case selection process, both the BMW i3 and Fiat 500e were a reaction to increasing demands of governments worldwide to decrease the car industry's CO_2 emissions. Especially Californian legislation plays a crucial role in this context. Dijk et al. (2013: 138) argue that from "2005 onwards, there is a new momentum for electric mobility" due to a series of new climate protection targets and policies. Approximately that same time, BMW decided to introduce its project for the i3. And in Germany, the Federal Government defined electric mobility as a key component in its Integrated Energy and Climate Programme (IEKP) in

2007, being influenced by trends such as the Kyoto Protocol and emissions standards in California (Altenburg 2014: 30). Fiat, also, only started with the development of the 500e when they felt they could no longer avoid it and had to comply with California's ZEV mandates. Thus, both BMW and Fiat began to pursue the design of these specific vehicles at roughly the same time, and for the very similar reasons. They also, mysteriously, look somewhat similar to each other, as Figure 3 indicates.

Figure 3: A 2017 model BMW i3 (left) and a 2017 model Fiat 500e (right)

Source: Authors

3.2 Research methods

To explore our two cases, we chose a qualitative, historical methodology because this is well suited for rich and processual studies of phenomena in real-world contexts (Yin 2014). The BMW i3 and Fiat 500e were chosen because they constitute contrasting cases along multiple dimensions. We believe the case study literature would call our approach a mix of "typical" yet "diverse" cases (Sovacool et al. 2018). *Typical* case studies study common, frequently observed, and/or representative cases, and exemplify a stable, cross-case relationship. *Diverse* cases attempt to demonstrate maximum variance along a relevant dimension, so that they illuminate the full range of important differences. Our two cases are therefore typical (both involving the development of an EV) but not identical, as they vary in some of their features (innovation approaches, technical features)

In the first step of our research process, we compiled a large body of secondary literature—peer-reviewed articles, company reports, market assessments—on the two products and companies. In the next step, we reduced the material to its core contents by writing in-depth case studies on each of the two cases (Mayring 2014: 66). We then used qualitative analysis (Yin

1994; Blatter and Blume, 2008) of our data applying the categories of our conceptual framework. In the last step, we assessed the similarities and differences between the two cases to capture the global, technological and corporate dimensions shaping the development of the two innovations styles.

4. A case study of a transformative change-shaping innovation style: the BMW i3

As mentioned, our first case is that of the BMW i3, selected because it represents a transformative change-shaping approach to innovation.

4.1 Corporate product innovation

From a corporate product innovation standpoint, the BMW i3 possessed at least five special, interrelated features when it was launched (Blunck 2016).

The first was *lightweight construction.* The consistent use of lightweight materials in vehicle design is particularly important with electrically powered cars, as not only the battery capacity but also the total weight of the vehicle restrict their range. To compensate for the added weight of the electrical components, the BMW Group has achieved an innovative combination comprising an aluminum chassis and a carbon-fiber-reinforced-plastic (CFRP) passenger compartment attached to an aluminum frame. CFRP uses composite material out of carbon fibers and a synthetic matrix. Significantly, BMW chose to keep its CFRP production in-house. Rather than relying on external suppliers, they set up a joint venture with the carbon fiber manufacturer SGL (Jacob 2014). Vehicle manufacturers often choose direct ownership in conditions of supply chain risk, especially for critical inputs such as magnesium or cobalt, and given the availability of CFRP was limited, BMW decided they could not risk failure in supply for this key model.

Second, the i3 had a specially designed *electric drive train* with a modular lithium-ion battery system (generally at 19kW with 8 modules of 12 cells). Unlike other models, the lithium ion battery pack is replaceable at the modular level (meaning cells can be repaired or replaced rather than the entire pack).

The third feature was the *proprietary charging technology*. With BMW i 360°ELECTRIC, BMW currently offers a package of products and services for purely battery-powered and plug-in hybrid vehicles in 38 countries worldwide. The package is based on four features: comfortable, rapid, emissions-free charging at home; simple comprehensive access to public charging stations; flexible mobility for long-distance journeys; and an assistance service for maintenance and repairs. Furthermore, BMW is offering a service contract for electric power from renewable energies (PV, wind power, water power, biomass) provided by the energy partner company Naturstrom in Germany.

Fourth, BMW also sold *mobility-as-a-service* bundled with the vehicle. BMW's car-sharing service DriveNow (merged later with Car2Go at Mercedes) enabled users to rent BMW and MINI vehicles according to their needs. Under the brand name AlphaCity, BMW also offers a car-sharing scheme for businesses. ParkNow is an app- and web-based service that helps solve parking problems for users by having available parking spaces in partner car parks that can be booked online and making it easier to find roadside parking spots. ChargeNow is a BMW i mobility service that simplifies finding and using public charging stations run by various suppliers belonging to an international network. BMW i Ventures facilitates access to new technologies and opens up new customer groups, thereby reinforcing the strategic approach adopted by BMW i. Life360, MyCityWay, JustPark, ChargePoint, and ChargeMaster are examples of BMW i Ventures' strategic investments.

Fifth, for those that wanted it, the car had *optional extra-range* with a petrol engine extender of 205 miles total (330km, 2-cylinder petrol engine in model with range extender). Newer models of the i3, for example those being sold in 2018 and 2019, no longer offer the range extender in Europe.

In sum, from a corporate product innovation perspective, BMW used a value creating, change-shaping strategy grounded in the assessment of the "disruptability" (Schmidt and Druehl 2008: 363) of the market by trying to push new innovations like the lightweight construction and proprietary charging. This is coupled with a strategy of changing consumer mindsets by bundling the development of the i3 with new mobility-as-a-service solutions.

4.2 Functions of Technological Innovation

(F1) Knowledge Development and Diffusion

R&D is a major part of German automotive industry which in 2017 invested EUR 40,2 billion worldwide in R&D. This accounts for more than one-third of total global automakers R&D expenditures and 35 percent of the total investments of the German domestic industry in R&D (VDA 2017).

BMW clusters its R&D activities in four topic areas: (1) autonomous mobility, (2) connected mobility, (3) electrified mobility, and (4) mobility services. Between 2016 and 2017 alone, R&D expenditure rose by 18.3 % from €5.1 billion to €6.1 billion. In 2014, the network of suppliers declared by BMW Group (2017: 33) surpassed 12,000 across 70 countries.

Currently, BMW (like most other carmakers) remains dependent on imported battery technology, meaning the TIS for the i3 involves a global supply chain. The market technological leaders of lithium batteries manufacturing including those used in EVs are all from Japan, China and Korea. This is critical since Europe is falling behind in battery technology with respect to US but primarily versus Asian OEMs. However, recently there had been a series of announcements to start the deployment of lithium-ion battery giga-factories by several international and European groups and also individual companies during the next years. Reports suggest that at least seven new gigawatt-size battery factories are scheduled to start operating in Europe by 2020 (Derler 2018). In 2019, BMW will open an R&D facility and production for battery-cell development. The company is creating a scalable electric modular system (BMW 2017). In 2020, BMW intends "to fit all model series with any drivetrain, according to demand".

Four facilities are involved in manufacturing the i3: the carbon fiber manufacturing facility (jointly owned with SGL Carbon) in Moses Lake, Washington, United States; the factory in Wackersdorf, Germany, where the carbon fiber is converted into fabric; the Landshut, Germany plant where the fabric is used to form the CFRP body; and the assembly site in Leipzig, Germany, where the vehicle is made (Jacob 2014). This supply chain begins in Otake, Japan in a joint venture with Mitsubishi Rayon Co. Ltd. and the SGL Group, where they produce the fiber precursor material needed for the BMW i3. Bakewell (2018) estimates the total investment in the carbon fiber supply chain at about $1 billion, although it could be much higher. A key element in BMW's thinking was to have end-to-end traceability in the material from Japan to the final car. Thus the same piece of equipment is used every time for the same material for the same component, to reduce the risk of process variability and hence error. This makes the logistics more complicated, and added cost, but was considered vital to ensure confidence in the repeatability of the manufacturing process.

Automotive patent data plays a key role in illustrating the EV trajectory. Prior to this trajectory, Dijk et al. (2013: 136) write that "80% of the patents were awarded to ICE-related technology, against only about 20% for technologies associated with pure battery EVs and Hybrid EVs". With the "tech innovation drive" gathering pace as car makers accelerate their efforts in developing electric and driverless cars, the number of car industry patents has risen by a fifth in five years (Smith 2018). In 2017, BMW filed the most automotive patents (113) among all those in Europe, coming ahead of Peugeot Citroen, Honda, Audi, Renault, and Volkswagen (Smith 2018).

(F2) Entrepreneurial experimentation

The i3 is the latest in a 40-year progression of EVs and BEVs. The recent history of the i3 starts in 2007, when BMW launched a project to explore sustainable mobility solutions, called project “i.” Project i was introduced at that time by CEO Norbert Reithofer, and presented by BMW as an “integrated approach” to innovation cutting across dimensions as diverse as vehicle concepts, materials and recycling, mobility services, and drivetrains (among others) as Figure 4 summarizes. At first, the project was established outside of the corporate structures and the project leader Ulrich Kranz had to report directly to the board of management (Freitag 2013). Field trials with conversion electric vehicles were set up in cooperation with expert partners from universities and research institutions for scientific monitoring and with partners from the infrastructure sector as well as the energy sector. Starting with the first step in 2009 in the United States and in Germany, private and corporate pilot customers rented EVs from a fleet of over 600 MINI E cars with the same powertrain that the i3 later received. Between 2009 and 2012, data from more than 16 million kilometers (10 million miles) driven by customers in the United States, Germany, the United Kingdom, France, Japan and China were gathered. More than 15,000 people applied to rent a MINI E, 430 private households took part in extensive mostly face-to-face interviews and 14 fleet user companies actively participated in the study (Ramsbrock et al. 2013). At the end of 2011 the second step of the learning projects for BMW i began. A fleet of over 1,000 BMW ActiveE vehicles, conversions of the BMW 1 Series Coupe, was launched in several countries. This part of the field trials focused more directly on technological innovations for EVs. BMW reiterated at the 2017 “International Motor Show Germany” in Frankfurt that it plans to produce 25 electric models (including a dozen all-electric vehicles) by 2025, and increase their range up to 700 km (Auto123 2017). Two noteworthy models were produced, the i3 released in 2013, and the i8, a PHEV sports car released in 2014. Most recently, in December 2018 BMW announced that they intend to launch the iX3 BEV in 2020, followed by the i4 and the iNext in 2021, so that by 2025 BMW has 25 electrified models in its range including 12 fully electric cars (BMW Group 2018b).

Figure 4: Summary of Project i Innovation Attributes at BMW

Source: Scott 2013

(F3) Market Formation

BMW undertook significant marketing for the i3. In terms of sales, BMW (2018) noted that 2017 reached a milestone when they sold the 100,000th electric vehicle worldwide (total sales for that year surpassed 103,080 cars). It notes that the i3 in particular leads the market for EVs in Europe. It also saw a 15% increase in annual sales. Table 2 shows BMW i3 registrations in Europe (including Norway) during the year 2017 ranked at second place with 7% market share and 20.855 units. During the first half of 2018 the vehicle has sold 1751 units in Germany (Bekker 2018), ranked fifth; first is the Renault Zoe with 2691 and second is the VW Golf with 2561.

Table 2: Registrations in Europe for BEV and PHEV Models (2017)

BEV and PHEV Model	December	2017 Full Year	EV Market Share
Renault Zoe	3,380	31,410	10%
BMW i3	1,979	20,855	7%
Mitsubishi Outlander PHEV	1,837	19,189	6%
Nissan Leaf	486	17,454	6%
Tesla Model S	2,451	15,553	5%

Total	**33,738**	**306,143**	**100%**

Source: Modified from Pontes 2018.

(F4) Influence on the direction of search

Even though BMW sells automobiles globally, our framework does account for the influence of national-level policies on manufacturing strategy. There, BMW has certainly benefited from its location in Germany. Germany has implemented EV policies pushing R&D and pilot projects and started in 2016 a customer rebate of EUR 4,000 for each BEV listed below EUR 60,000 in tag price and EUR 3,000 for PHEVs (plus an exemption from ownership tax for 19 years if bought before 2020) (Zhou 2017).

That said, many commentators have critiqued German policy for being too weak or too late. Some suggest that the German government's long-lasting hesitation to introduce a buyer's premium was rooted in an effort to protect the German car industry at least until German carmakers offer some BEV and PHEV models of their own (Mazur et al. 2015). Bubeck et al (2016) found that the present buyer's premium of EUR 4,000 for BEVs does not cover even nearly for the cost penalty incurred by buyers. Under this framework car dealers have potential difficulty offering such an expensive proposition that also presents challenging technical issues with battery-range. Germany's company car (battery) tax is 1% applied over the car price after it has been discounted. The discount on the price for pure EV (both BEV and PHEV) in 2017 was €300/kW up to €8,000 total and in 2018 €250/kW up to €7,500.

The somewhat timid policy environment in Germany could be attributed to industrial apprehension that incumbents are having. Such anxiety could relate to worries that 1) EVs will be half as profitable as ICE cars, 2) then outsourcing of more component manufacturing, 3) German jobs losses and, 4) even a somewhat overstated concern on "uncertainty" that EV would not sell enough which will create a huge problem for the industry, for employees and for European governments. In their comparison of advocacy coalitions in California and Germany, Gubman et al. (2016: 15) highlight that even though there is IT-transportation activity in Germany, these "are more focused on incorporating IT into traditional vehicles (such as in car-sharing), and on promoting the interests of traditional ICE manufacturers, and less focused on transportation electrification". The feeling is that as if it was fine by being a catch up follower (with all the implications that may carry with it). There are signs of defensive strategies, not without logical reasons, that incumbents and governments are following upon on the fashion described by Smink and Hekkert et al. (2013) “keeping sustainable innovation on a leash”.

Autonomous driving is another influencing factor. In the automotive industry, autonomous driving has attracted much more attention by the traditional car manufacturers than electrification. BMW has changed track with project i because of the low sales figures of the i3 in comparison to the Tesla Model 3 for example and now concentrates its efforts on developing an autonomous electric car. Upon writing these lines sales for half of the year records in USA show that Tesla small sedan (38,617 cars) is outselling all other consumer EV including the i3 (3,968 cars) despite the range-extender-petrol-engine (Loveday 2018). Moreover, if the Model 3 is compared with ICE passenger vehicles it is already reported at 7th place in sales on the month of July and 10th place for total sales year-round in 2018 (up to July), despite the slow ramp-up during the first six months (Malone 2018). Some voices are placing it at 5th place by yearend among all passenger cars.

In comparing the international *direction of the search* with the local one, it is necessary to take into account that the cases of the strong EV sales in Norway, China and the case of Tesla and other EVs in USA points towards the existence of a dormant demand potential that cannot be perceived easily unless the right combination of market conditions and product performance/attractiveness are in place.

(F5) Resource Mobilization

In total, the BMW Group is said to have invested more than € 2 billion in the development of the production of the i3 and the i8 (disaggregated numbers for Project i were not available). However, traditional ICE manufactures in Germany and other countries seem to be trying to slow down the transition process. Until the end of 2017 only Tesla had been able to achieve substantial progress on deploying their superchargers network in Europe (as well as in USA and China). An association between Daimler, Ford, Volkswagen, BMW, Shell and other petrol stations brands for light cars and trucks have partnered to deploy the first fast charging network in Europe, IONITY, for 400 stations (starting in Germany, Austria and Norway). This, similar to batteries, underscores the global nature of charging research and cooperation at this stage. The first announcement was done from the beginning of 2017 but only recently (one year later) it has started to deploy the first 20 stations (Hage 2017; Lambert 2018). More broadly, British Petroleum, Shell, and Total report investing $20 billion or more on placing EV chargers within their own petrol stations (Ward and Hook 2018).

(F6) Legitimation

BMW reports adhering to resource efficiency, recycling management, and environmental management (including supply chains) for the i3. According to their promotional materials, intelligent design and the use of secondary and renewable raw materials enable the company to reduce the consumption of valuable resources. This fits into a vision propagated by BMW that they are a steward aiming to be the most resource-efficient premium provider of individual mobility. Another proclaimed contributor to sustainability is related to the internationalization of sourcing to increase local sourcing. In particular, in the manufacturing of the i3 specifically, BMW uses 100% hydroelectricity at its Moses Lake plant and wind turbine energy at its Leipzig, Landshut and Wackersdorf plants (Scott 2013).

Country wide and local coalitions had been observed advocating for urban niches derived from concerns on carbon abatement, air quality, threat of EU legal action and driving prohibitions in urban areas that regularly exceed the limits (Kemfert 2016; Gubman et al. 2016). The EU, the German federal ministry for Environment, Nature conservation, Building and Nuclear safety (BMUB) and the National Electromobility Development Plan (NEDP) (individually and/or collectively) had also been advocating for banning diesel vehicles from city centers (within air pollution limits policy) and also a broad industrial policy to promote technological leadership including the electrification of transportation. In 2018, several rulings by German courts have opened the door for bans of diesel vehicles in city centers and on certain routes where pollution levels are particularly high.

Another challenge, rightly or wrongly, is perceived range. Schneidereit et al. (2015: 204) have conducted a survey of early adopters of electric vehicles in Germany and noted that: “Due to adaption processes toward high range mobility in the past 100 years, a widespread introduction of BEVs within the next few years seems to be challenging. The limited-range BEV is a highly incongruent product that cannot easily be integrated into existing schemata of automobility.”

(F7) Development of positive externalities

With project i, the BMW group primarily intended to develop a new electric vehicle suitable for urban mobility. But the project was also supposed to have spillover effects by developing new technological features that can later be used for other BMW models. Unlike the Fiat 500e, the BMW i3 was at least intended to bring in long-term profits. Furthermore, and similar to other automotive firms, the BMW Group is investing in a number of startups through its subsidiary BMW i Ventures, named after project i. According to online news sources, BMW is the only German carmaker with a venture capital arm, even though the amount of money BMW is investing is fairly small compared to its competitors.

Just as other traditional car manufacturing companies, BMW stopped referring to itself as a carmaker and is using the terms mobility provider or technology company instead. After the initial introduction of the i3 and the i8 which both boosted BMW's reputation as an electromobility pioneer, BMW has been criticized for failing to keep up the pace and lost confidence when the new vehicles did not gain traction with buyers as expected (Grundhoff 2017). Only recently, rumors were circulating that the lightweight carbon-fiber construction that was once hailed as a groundbreaking innovation "might be a thing of the past". According to an influential online magazine, Oliver Zipse, BMW's board member, said "The i3 and the i8 will be singular vehicles" (Boeriu 2018). It fits in this picture that the first car of the new BMW electric offensive does not build on the carbon-fiber construction but on the chassis of the already existing ICEV BMW X3. Perhaps under this framing, the i3 is a success, but only as an experiment. The change-shaping innovation style of BMW has turned into a sustaining style because of lacking success for the i3 and the overall development of the EV market which failed to live up to the expectations.

5. A case study of a conservative sustaining innovation style: the Fiat 500e

Contrasted with the BMW i3, our case study of the Fiat 500e is one of a conservative sustaining innovation style with fairly limited expectations for learning, and an emphasis simply group compliance with low-carbon regulations.

5.1 Corporate product innovation

The Fiat Group (now the Fiat Chrysler Group, or FCA) is the largest industrial enterprise in Italy and one of the founders of the European motor industry. FCA currently faces challenges, with Jeep and Alfa Romeo reporting rising sales or revenues, but Fiat struggling in Italy, with sales overall falling by 13 percent across all of FCA and Fiat in particular falling 20 percent (Malan 2018). Worth noting is that in Italy, EVs and hybrids must be imported, and also that rising costs and mounting pollution and emissions standards suggest that diesel will no longer be a viable fuel for Fiat vehicles (Campbell 2018a). Their current strategy is to "focus the majority of our research efforts in two areas aimed at improving vehicle efficiency and reducing fuel consumption and emissions: vehicle energy demand (including weight, aerodynamic drag, rolling resistance, heating, air conditioning and auxiliaries) and powertrain technologies (engines, transmissions, axles and drivelines, hybrid and electric propulsion and alternative fuels)" (FCA 2017: 12).

The 500e is a sharp contrast to the i3, as Fiat has said it does not want to sell it. The CEO of FCA, the late Sergio Marchionne, had publicly attacked the 500e because Fiat lost money on every unit it sells. In a speech to the Society of Automotive Engineers 2013 World Congress in Detroit, Marchionne said of the 500e, "we will lose $10,000 per vehicle. Doing that on a large scale would be industrial masochism" (quoted in Rovito 2013). He also said a year later, in 2014: "I hope you don't buy [the 500e], because every time I sell one it costs me $14,000" (Car and Driver 2013). More recent numbers from 2017 suggest as much as $20,000 may be lost per vehicle sold (Gilroy 2017). *Car and Driver* (2017) thus aptly named the vehicle the "black sheep of the Fiat Chrysler Automobiles family" and a "thorn in the side," noting it was built to appease the state of California and its zero-emission mandates.

Fiat cross-subsidies the loss by the clean air credits which they can use to keep selling less efficient vehicles, so called "gas guzzlers," such as the Viper and other SRT models (Devereux 2013). Marchionne has also been on record as criticizing government regulators for making mandates (such as those in California), for calling for more use of fossil fuels in automotive technology (such as natural gas), and for focusing instead on fuel economy improvements for traditional cars, rather than investing in EVs (Rovito 2013).

In terms of styling, the similarities between the 500 ICEV and 500e EV are apt: on the 2013 model, only 3 exterior panels and the floor were changed (Devereux 2013).This perhaps highlights Fiat's relative input (or lack thereof) to the development of the 500e. However, on the inside, there are numerous alterations to the original 500 model such as a reworked body structure to balance the increased weight because of the heavy batteries and the regenerative braking system (RBS). Interestingly, the Fiat 500e is only available overseas, more precisely in California (and to a lesser extent in Oregon).

Interestingly, the Fiat 500e has received almost uniformly positive reviews. The following four statements capture a sample of the tone and scope of critical reviews:

- *Plugincars.com*: “I found the 500e noticeably quicker and more maneuverable than the LEAF. It was a blast tossing the small electric two-seater around the crowded city streets, hills, and highways of L.A…the most affordable, stylish and fun (but somewhat cramped) electric car on the market.”
- *Wall Street Journal*: “The Fiat 500e is just awesome, a nutty electric elf of a car. All dressed up in Playskool aero pieces and available in Life Savers colors, the 500e feels like the big-kid toy the Fiat 500 always wanted to be, with an otherworldly electric hum to go with its whimsical aesthetics…It’s a lot of fun to drive.”
- *Autoblog*: “The 500e is a blast, and we actually like it better than its liquid-fueled 500 cousin… the heavy battery pack placed low in the 500e means the EV is more surefooted… When you’re driving around the city in the 500e, you quickly forget you’re not driving in a normal car.”
- *Green Car Reports*: “The 2013 Fiat 500e may be a compliance car, but its engineers created an electric car that’s so much fun to drive that seemingly they want it to be more.”

Nonetheless, the technological and market development of the 500e has been staggered. The drivetrain system being developed extramurally by Bosch is key because, what is arguably the most significant technology cluster, the power and drivetrain system, is not developed by Fiat.

Overall, when Fiat developed the 500e, they used a value maintaining innovation style based on the assessment of the “sustainability” (Schmidt and Druehl 2008: 363) of the market not hoping for a major breakthrough. The alterations made to 500e in comparison to the 500 were mostly the result of the necessity to “accommodate and protect the battery” (Vasilash 2013).

5.2 Functions of Technological Innovation

(F1) Knowledge Development and Diffusion

Historically, in scale-intensive sectors such as automotive manufacturing, the main sources of technology are in-house design and production engineering departments, with specialized suppliers - mechanical and instrumental engineering, and software firms – adding their contribution to the overall design. On the contrary, Dijk et al. (2013: 137) note that "[m]ore than with diesel and gasoline innovations, which have been developed only partly by first-tier suppliers (such as Bosch, Denso, Valeo and Delphi), EV research occurred mainly within the supplier network". Indeed, it may be that EV powertrains are more likely to be developed by suppliers in this era, because of the long-run trend to vertical disintegration. Bosch produces the electric drivetrain for the Fiat 500e. While Fiat is arguably not highly innovative with regard to EVs, Bosch does have a highly innovative character: spending €7.3bn on research and development in 2017, 64,500 people work in R&D at Bosch (2018a) where they spend around €400m each year on driving e-mobility forward (Bosch 2018b).

With regard to battery technology, most of what was stated for the BMW i3 is also true for the Fiat 500e. Currently, Fiat, like BMW and most other automakers, remains dependent on imported battery technology, meaning the TIS for the 500e involves a global supply chain. The Fiat 500e is manufactured at the Toluca Assembly Plant in Mexico, along with the Dodge Journey. To prepare for the build of the 500e, extensive changes were made in the plant, ranging from new torque tooling to 110 new dies, from five new automated closure lines to a fully automated PVC sealant application system (Vasilash 2013). With regard to patents, Fiat Chrysler Automotive does not feature in the top 6 tier of automotive innovators (see BMW i3 case study).

(F2) Entrepreneurial experimentation

In terms of Fiat's innovation activity, the Fiat 500e is more incremental, essentially adapting a pre-established vehicle brand (the Fiat 500) rather than pursuing an ambitious change-shaping pathway such as BMW's Project i. It appears that Fiat chose the path of least resistance by choosing their best-selling European car to convert, rather than develop new innovations.

As the market developed and the 500e began to sell, Fiat made alterations and improvements. Updated from the 2013 model, the 2017 500e had a new interior, and perhaps more significantly the new multimedia Uconnect system was added, which gives the driver greater control of the vehicle and helps track both the car and the drivers driving efficiency when on the road. However, this was the limit of technological changes and improvements as mechanically, the 500e "carried over to 2017 unchanged" (Car and Driver 2018).

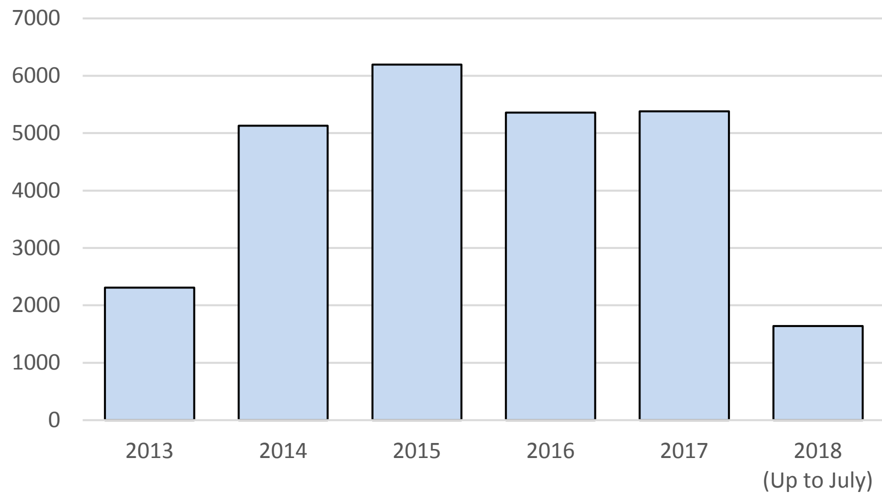
(F3) Market Formation

Market development for the Fiat 500e has been limited to California and Oregon, and Fiat does not appear to be reaching to a new market – not surprising for a product which, for each unit sold, loses money. Zhou et al. (2016) explain that "compliance cars" are manufactured in small numbers and sold only in California or states with similar mandates in place. Important to highlight is that Fiat have deliberately limited the market development of the 500e by isolating it in areas where markets are already established.

The evidence suggests that, as a compliance car, Fiat have not prioritized the market development of the 500e and it is likely that its development was driven by compliance rather than innovation. Fiat report sales data for the Fiat 500, 500L and the 500X, but they do not release any sales data for the 500e, supporting the notion that Fiat are not developing the 500e's market. Fiat may be reluctant to make public the sales figures about a product which they are required to sell by law to offset the environmental damage of their SUVs, particularly considering that they are set to make profits in 2018 of sales of said SUVs, rather than the 500e (Campbell 2018b; Campbell and Waldmeir 2018). Luft (2018) reports that although sales of Fiat vehicles dropped by 46% between 2017 and 2018, FCA sales overall increased, with sales of Jeep increasing by 14% and Dodge increasing 41 percent. Thus, overall it appears that market development for the 500e is low, and low-priority.

The lack of official figures from Fiat makes sales data on the 500e somewhat patchy. However, *Inside EVs* has compiled a meta-table of sales figures and release monthly sales patterns, which we display in Figure 5. Excluding a spike in early 2015, sales have been sporadic and consistently below 800 units per month, with 2017 annual sales showing a slow decline throughout the year, and 2018 sales thus far remaining consistently below 300 units per month. This supports the notion that the 500e have not been a priority for Fiat, despite the ZEV.

Figure 5: Sales Figures for the 500e in the United States (2013-July 2018)



Source: Inside EVs (2018) ‘Monthly Plug-In Sales Scorecard’.
Available at: https://insideevs.com/monthly-plug-in-sales-scorecard/ [Accessed 10/08/18].

In addition to the lack of innovation the car has been plagued by recalls (which exacerbates the lack of sales and market development explored above), the 500e being recalled for the fourth time by June 2015 (DeMorro 2015), two years after it went on sale. This further suggests that the 500e is a failure. Costs not being internalized by FCA (they lose money on each one sold) has kept the price high, sales and market development is constrained, and technological development is facing an uncertain future.

(F4) Influence on the direction of search

The United States federal government has enacted policies and legislations that promote the U.S. market for EVs. The American Recovery and Reinvestment Act of 2009 established tax credits for purchasing electric vehicles (between $2,500 and $7,500 per vehicle, depending on the battery capacity) and conversion kits to retrofit conventionally powered vehicles with electric vehicle capability ($4,000 per vehicle, maximum). The US federal government first introduced incentives for plug-in electric vehicles (PEVs) through the American Clean Energy and Security Act of 2009, which provided a tax credit of up to $7,500 for a new PEV purchase. Soon after, in December 2010, two mass-market PEVs were introduced, the plug-in hybrid electric vehicle (PHEV) Chevrolet Volt and the battery electric vehicle (BEV) Nissan Leaf.

Of huge significance are California’s clean air laws – ‘California Ambient Air Quality Standards (CAAQS)’ - which are designed to reduce the harmful effects of air pollution. The

California ZEV mandate "requires the six carmakers that sell the most vehicles in the state to deliver specified numbers of vehicles with no tailpipe emissions during model years 2012 through 2014" (Voelcker 2013). Hence, Fiat developed the Fiat 500e.

(F5) Resource Mobilization

As mentioned above, according to the deceased Fiat CEO Marchionne, Fiat lost as much as $20,000 a car on the 500e. How much Fiat invested in the development of the 500e is undisclosed. InsideEV (2013: 1) stated that "Fiat is big into diesel and natural gas, not electrification and that's not likely to change for quite some time". After the scandal involving Volkswagen cheating on emissions tests for their diesel vehicles in 2015 and 2016, however, FCA announced a € 9 billion investment in electrification across most of its brands over the next five years in 2018.

(F6) Legitimation

As the 500e is an example of a "black sheep" and "compliance car," FCA had to sell a certain number of 500e's so that they could continue to sell more of the faster, but more polluting, ICE sports cars like the Dodge RAM, Viper, Challenger and SRT models. To quote from Zhou et al. (2016: 18), "certain PEV models were built specifically to comply with ZEV mandates. These so-called 'compliance cars' are typically conversions of existing ICE vehicle models, manufactured in small numbers, and sold only in California or states with similar mandates in place. While compliance cars do increase the number of PEVs in circulation, they may be sidestepping the original intentions of ZEV mandates, which broadly speaking are to increase electric miles traveled, reduce emissions, promote technology learning, and encourage manufacturers to develop affordable, mainstream, mass-market PEVs." Fiat CEO Marchionne told Bloomberg (2017) in an interview the reason for the development of the 500e: "Because of the time-frame chosen in Europe, we have to electrify. […] But if you tell me that this is the answer, I say no." This clearly points to the fact that the 500e was solely developed as a compliance car and that up until recently Fiat did not pursue electrification as an innovation strategy but rather as a reaction to external political pressures, e.g. by the European Union and California.

(F7) Development of positive externalities

Contrary to the statements from Marchionne, Fiat has changed its corporate strategy and committed to make EVs only by 2022. In June 2018, Fiat announced the release of an all-new 500e in 2020 and another all-electric 500 model, a Giardiniera compact wagon sometime before 2022. However, another factor explaining Fiat's strategy around the 500e is that Fiat is more strongly pushing another low-carbon vehicle in Europe, the bi-fuel CNG Fiat Punto Evo Natural Power, intended to be far cheaper, and to compete with the Ford Fiesta, Toyota Yaris, and the VW Polo (Rusich et al. 2015). Abroad, the Fiat Group has been backing the compact Mio, especially in Brazil (Brondoni 2010). Similarly, their latest Annual Report does not mention the 500e when talking about plans and development of "Hybrid and Battery Propulsion" cars. Instead, it notes the launch of the Chrysler Pacifica Hybrid (with an efficiency rating of 84 miles per gallon equivalent) and belt starter generator ("BSG") technology that offers a claimed improvement in fuel economy and a reduction in CO_2 emissions (Fiat Chrysler Automobiles 2017).

6. Conclusion and Implications

In comparing the developments of global corporate product innovation and technological innovations systems around the BMW i3 and the Fiat 500e, we draw numerous conclusions.

Although both products can be regarded a response from automotive firms to the imperative of decarbonisation, they represent initially different approaches: with the i3, BMW decided on a transformative change-shaping, fairly radical approach to create new value by launching an innovation project as a niche within the own company to develop sustainable "mega city vehicles" which later became an own sub-brand. They manufactured a new car with a unique design and prominently proclaimed that the "future is electric". With the 500e, Fiat decided on a conservative sustaining, fairly constrained approach to maintain value. They mainly stuck to the tried-and-tested design of a recently relaunched model and openly portrayed the development of the 500e as externally imposed. As Table 3 indicates, the innovation styles, profiles and functions for each product differ markedly.

Table 3: Technological Innovation Styles and System Functions for the BMW i3 and the Fiat 500e

Function	BMW i3	Fiat 500e

Innovation style	**Transformative change-shaping:** BMW started with value creating strategies by developing an all new electric vehicle with highly innovative features and over time switched to more value maintaining strategies.	**Conservative sustaining:** Fiat started with a clear value maintaining strategy by developing a compliance car and recently seems to have switched to a value creating strategy.
(F1) Knowledge development and diffusion	More investment in R&D, in-house production, joint venture for carbon fiber production, leading in patents filed	Less R&D, fewer partners involved in the development of the Fiat 500e, fewer patents filed
(F2) Entrepreneurial experimentation	Extensive field trials at different stages of the development process	Fiat 500e is a conversion of an existing product, no known experimentation
(F3) Market formation	Intensive marketing “Hello Future”, more 100.000 vehicles sold worldwide	anti-marketing, vehicles only sold in California and Oregon as a compliance car
(F4) Influence on the direction of search	Germany pushing R&D projects in the incumbent industry and trying to protect the domestic car industry, wants to become a leading market and leading manufacturer of EVs	California’s ZEV mandate as the sole reason to develop a compliance car
(F5) Resource mobilization	More than EUR 2 billion investment in project i	At first low investment strategy but recent announcements of heavy investments in electrification
(F6) Legitimation	Sustainability strategy, but also attempts to preserve the industrial tradition	The Fiat 500e is the “black sheep” of the Fiat group to sidestep the California ZEV mandate
(F7) Development of positive externalities	Development of new technological features that can also be used for other models, shift in self-reference from carmaker to mobility provider	Fiat announced the development of a new all-electric Fiat 500 in the near future

Source: Authors

Second, drawing on insights from our conceptual framework, which touches on corporate style and global innovation systems which mediate TIS, we can conceptualize both the BMW i3 and the Fiat 500e as examples of local innovation subsystems that in principle compete internationally on the same highly standardized valuation subsystems (even though the Fiat 500e is limited to a few thousand units sold in California and Oregon). BMW and Fiat Chrysler Automobiles are examples of internationally active firms which are able to couple the global, technological, and corporate dimensions of EV development together, albeit using different innovation styles, especially in entrepreneurial experimentation and market formation.

These innovation subsystems must navigate at least three different sets of selection pressures. First would be those specific to each of the models being manufactured, i.e. the more narrow TIS surrounding the i3 (with its distinct design specifications, supply chains including carbon fiber, performance parameters, etc.) as well as the 500e (an equally distinct set of specifications, supply chains, and parameters). The TIS framework offers a remarkably effective heuristic for capturing these dimensions. Nonetheless, it fails to fully capture two additional levels of pressure. The second level of pressure relates to the dynamics within each corporate entity as a whole, the overall strategy of BMW and FCA and how they may learn and innovate across different automotive models and manufacturing processes. Here, the i3 becomes a part of BMW's overall strategy of electric mobility, and shows strong synergies with the i8 and other future products. In contrast, while the narrower TIS in favor of the 500e was successful in that the product got built and users seemed to like it, it ran counter to the overall strategy of FCA, thus becoming framed as a "black sheep." This second dimension of pressure underscores the limitations to examining only a single vehicle, and instead to a broader portfolio of vehicles within a firm. Third and lastly we have complex but nonetheless significant global pressures shaping both the innovation attributes of a specific vehicle model and corporate strategy, such as climate policy imperatives and zero emissions targets. These pressures are so strong, and uniform in their directionality, that despite having different products and strategies, both BMW and FCA begin to converge in their attempts to embrace electric vehicles.

Which brings us to our final point. There is a temporality to the automotive manufacturing innovation styles depicted. Despite the inherent differences in the BMW i3 and Fiat 500e, the strategies of the two companies seem to converge over time due to the general market development and policies around electric vehicles. Also, the narrative about the innovation dynamics of Fiat become more complex given that the FCA group as a whole appears to have learned from the process and are now more actively innovating in the area of electric mobility for other models and markets. This suggests both innovation styles are malleable to external pressures and especially shifts in the global policy landscape. BMW has begun to look more like Fiat in terms of statements favoring conventional technology, and Fiat has more recently begun to public endorse electrification. So far, the assumption by the BMW management "that enough young wealthy urban consumers will be willing to buy a car that combines sportiveness, technological innovation, and a unique and appealing design with an image of environmental sustainability" (Altenburg 2014: 34) is awaiting confirmation. Fiat, by contrast, at first involuntarily entered the electric vehicle market but then presented a conversion of its best-selling small car which was frequently praised for its design. In 2018, Fiat also felt the need to present a more ambitious plan for electrification and invest more money in this trajectory. The pathways at BMW and Fiat are malleable and shifting. Unlike another study on car manufacturer's responses to emission policies suggests (Wesseling et al., 2015), we find that not all firms change their strategies from conservative sustaining, value maintaining to more transformative, change-shaping, value creating strategies, or maintain their strategies indefinitely.

The assumption of linear progress that lies behind the shift from value maintaining to value creating strategies does not hold up when comparing the innovation styles of BMW and Fiat. By contrast, firms can also shift from value creating to value maintaining strategies if the desired outcomes do not materialize. It seems that Fiat has begun to reject its "black sheep" strategy and embrace electrification as the future of mobility while BMW started out with high aims but so far, more than ten years later, has begun to scale back its ambitions. This reminds us that corporate hubris can sometimes encompass arrogantly overreaching, but in other times stubbornly holding back.

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